Venus Suface Sampling and Analysis

Completed Technology Project (2015 - 2018)

Project Introduction

This effort is developing the technology to transfer particulate samples from a Venus drill (being developed by Honeybee Robotics in a Phase 2 Small Business Innovative Rearch task) inside a lander pressure vessel and thermal barrier and to present them to instruments for analysis under Earth-like temperature and low pressure environment.

The overall objective of this task is to develop a Venus surface sample acquisition and transfer system that can reliably provide particulate samples of sufficient quantity and presentation location for instruments located inside a lander to perform useful analysis. Development priority was given to the high temperature, high pressure external functions and the transition element between external high-pressure, high-temperature conditions and the internal low-pressure, room-temperature conditions where the instruments would operate, because that is where most of the mission risk resides. Fortunately, JPL has partnered with Honeybee Robotics on the Venus lander mission and they have already developed prototypes of a rotary drill, electric actuators and a gear box that operate at high temperatures. Honeybee has further matured their technology in this, the first of two years of a separate Phase 2 SBIR task. The JPL strategy for this R&TD proposal is to focus on component and subsystem technology development to provide the other required functions of the overall system. Development in this sense consists of design, fabrication and successful testing of prototype hardware under a relevant environment (TRL 5). The guiding philosophy of this effort has been to expand beyond the Soviet Venera sampling solution that was limited to a single sample from a single drill delivered to a single instrument in a lander resting on flat (<10° slope) terrain. In particular, there is a strong desire to be able to accommodate two instruments such as JPL's CIRS (a Raman Spectrometer) and PIXL (an X-ray fluorescence instrument) for mineralogical and elemental abundance analyses, and to present the surface samples in a benign environment to minimize adaptation of these instruments for use at Venus. We accepted this premise and made other assumptions in this task, understanding full well that mission trades may require ongoing adaptation of the sample system development as trades are closed and decisions made. The quantitative capability goal is that two particulate samples would be provided for analysis by two instruments either as soil/dirt from the surface or as cuttings created during the sample excavation process. The sample would be presented to the instruments in a sample cup of size >2 cm in diameter and with a depth of >0.1 mm given lander orientations of up to 20° from horizontal. The sample measurement environment would be low temperature (notionally 30 °C) and low pressure (< 1 atm). It is assumed that one sample would be from the weathered surface material at a depth of 0-2 cm and the second from presumably unweathered material (if drilled from competent rock) at a depth of 2-4 cm. The sampling system will accommodate a wide range of surface material hardness from loose soil to basalt (7-8 on the Moh scale).

JPL_IRAD_Activities Project

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Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Center Independent Research & Development: JPL IRAD

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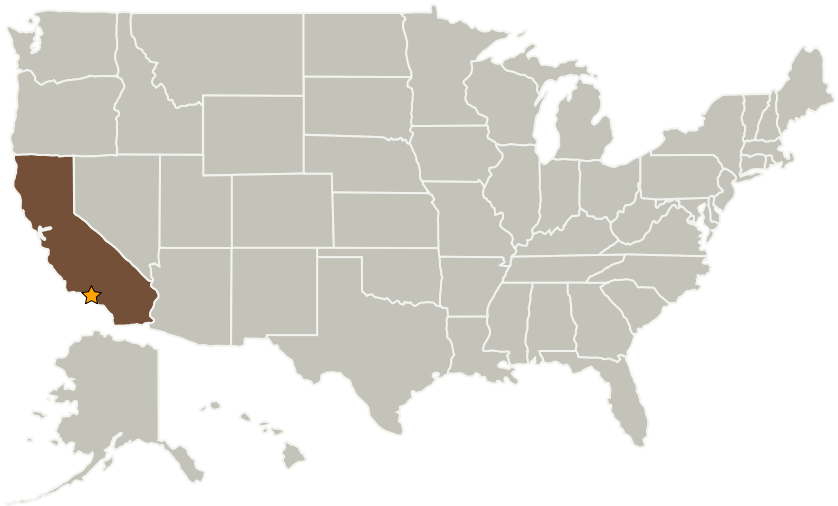
Anticipated Benefits

For over 30 years, no Venus mission has made any in-situ measurements of the Venus atmosphere or surface. NASA's only mission to Venus that included a planetary probe, the Pioneer-Venus Multiprobe mission, was launched in August 1978, and the final Soviet Venus surface mission, VEGA-2, landed in 1985. In the most recent Planetary Decadal Survey, "Vision and Voyages for Planetary Science in the Decade 2013-2022," a Venus In Situ Explorer (VISE) mission concept was identified as one of the five recommended candidates for the upcoming New Frontiers 4 mission competition. JPL has previously proposed the SAGE Venus lander mission concept during New Frontiers 2 and 3 (NF-2 and NF-3), and progressed as far as Step 2 (Phase A) during the NF-3 competition. However, both prior attempts received major weaknesses for the proposed surface sample measurement approach and therefore formulation and development of an improved approach is needed that can withstand scrutiny. The research proposed here supports that goal by developing critical component and subsystem technology for a bring-the-sample-inside the lander architecture option. The prototyping and relevant environment testing planned in this effort should help convince review boards of the viability of the proposed approach.
This task has demonstrated that drill cuttings can be effectively transported by Venus atmospheric pressure to a sample analysis window. This task is ready to demonstrate that this sample and window can be moved between Venus pressure and normal Earth conditions (~20C and <1 bar) for analysis by instruments that have not been re-engineered for Venus conditions. This task has demonstrated that a NAGRS instrument can significantly improve over the analysis uncertainties achieved in the Soviet missions decades ago.

Primary U.S. Work Locations and Key Partners



Project Management

Program Manager:

Fred Y Hadaegh

Project Manager:

Fred Y Hadaegh

Principal Investigator:

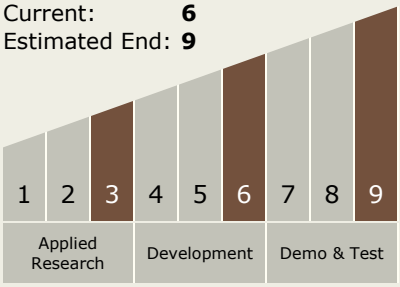
Brian H Wilcox

Co-Investigators:

James L Lambert
Joseph P Melko

Technology Maturity (TRL)

Start: **3**
Current: **6**
Estimated End: **9**



Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.3 Manipulation
    - TX04.3.4 Sample Acquisition and Handling

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Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
Honeybee Robotics, Ltd.	Supporting Organization	Industry	Pasadena, California

Co-Funding Partners	Type	Location
Honeybee Robotics, Ltd.	Industry	Pasadena, California

Primary U.S. Work Locations
California

Images

JPL_IRAD_Activities Project Image
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(https://techport.nasa.gov/image/26035)